

Tagging and Playback Studies to Toothed Whales

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LONG-TERM GOALS

There has been growing recognition that atypical mass strandings of beaked whales may coincide with naval exercises that use mid-frequency sonar, but the causal chain of events from sound exposure to stranding has not been elucidated. Even less is known about potential risks to other species of odontocetes or for other signals. The proposed research is part of a collaborative research program whose long-term goals are to:

- Compare responses of beaked whales vs other odontocetes to playbacks of mid-frequency sonar sounds vs other anthropogenic signals.
- Conduct combined visual and acoustic surveys for beaked whales and other cetaceans along with collecting oceanographic data for input into models to predict beaked whale distributions based upon characteristics of their habitats.

The ultimate goals will be to predict the distribution of species at risk from sonar, to define dose-response curves for risk to beaked and other whales for exposure to naval sonars, and to suggest improvements for monitoring and mitigation. The specific data gap that this project aims to fill is a lack of response data from any beaked whale species outside of a naval range, where they frequently are exposed to naval sonars, and to Cuvier's beaked whale, *Ziphius cavirostris*, which is the species most represented in the record of atypical mass strandings associated with naval maneuvers.

OBJECTIVES

The main objectives of this study involve

- Designing, planning, permitting, and conducting a study involving sound playback experiments with beaked and other whales carrying sound and orientation recording tags.
- Develop, test, and validate shipboard Passive Acoustic Monitoring (PAM) of marine mammal vocalizations for Detection, Classification, and Localization (DCL) during survey, focal follow and playback.
- Merge a survey mode with a focal follow mode that will involve tagging and controlled exposure

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14. ABSTRACT There has been growing recognition that atypical mass strandings of beaked whales may coincide with naval exercises that use mid-frequency sonar, but the causal chain of events from sound exposure to stranding has not been elucidated. Even less is known about potential risks to other species of odontocetes or for other signals. The proposed research is part of a collaborative research program whose long-term goals are to Compare responses of beaked whales vs other odontocetes to playbacks of mid-frequency sonar sounds vs other anthropogenic signals. Conduct combined visual and acoustic surveys for beaked whales and other cetaceans along with collecting oceanographic data for input into models to predict beaked whale distributions based upon characteristics of their habitats.				
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- Identify and improve management of habitats that host sensitive species (consistent with ACCOBAMS)
- Map the range of doses of noise to which animals are exposed
- Collect environmental data to support habitat modeling

APPROACH

This study involves a research cruise divided into two three-week field efforts in 2009 in the Mediterranean Sea. We had already conducted survey and tagging research (including tagging a *Ziphius*) in 2008 at this site, in collaboration with the NATO Undersea Research Centre, using their research vessel Alliance and staff. We collaborated in the field work with biologists from the Alnitak Marine Research Center from Madrid Spain. The following organizations and personnel are also engaged in the Med09 sea trial:

Visual Teams: Woods Hole Oceanographic Institute (WHOI), United States; Alnitak Marine Environment Research and Education Centre, Spain; bluWest Whale Watch, Italy; Conservation Information & Research on Cetaceans, Spain; Museo di Storia Naturale di Milano, Italy; NATO Undersea Research Centre (NURC), Italy; Politecnico di Milano – DIIAR Environmental division, Italy; Delfini Metropolitani; SPAWAR Systems Center Pacific (SSC Pacific), United States will collaborate on the collection, archive and analysis of the visual sighting data

Passive Acoustic Monitoring (PAM) Teams: NURC provided the CPAM tetrahedral array; Naval Undersea Warfare Center (NUWC), United States, provided a passive sonobuoy system and a tetrahedral array; Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA), Università degli Studi di Pavia provided two towed arrays and is collaborating in the collection and analysis of acoustic data; SSC Pacific is collaborating in the collection, archive and analysis of acoustic data.

Acoustic Source: NURC provided the acoustic source

DTag: WHOI provided the DTag equipment, tag boat operator, tagger, and tag technicians.

Data display, integration and archiving: SSC Pacific provided the visual data logging system, GIS integration of visual and acoustic data, and archiving and distribution of all cruise data

WORK COMPLETED

The Med09 cruise required extensive pre-cruise preparation and planning. Tyack applied for and received a new permit for scientific research on marine mammals from the National Marine Fisheries Service Office of Protected Resources. Cañadas, D'Amico, Southall, and Tyack met with members of the Spanish Departments of Defense, Environment, and Fisheries to present preliminary plans for the research and to obtain feedback on the most important issues to these Spanish departments. We also met with European biologists and representatives of environmental agencies and NGOs in Milan and with the US embassy in Rome to discuss the project and to coordinate with relevant agencies. We took part in the cruise planning meeting at NURC in April, had another meeting in Woods Hole in June to finalize the observation protocols and logging program and developed the test plan by June. Tyack worked with the 3S and Med09 visual observation teams to write up a protocol for visual observations.

The Med09 cruise left from La Spezia Italy on 29 July 2009, transited through the Pelagos Sanctuary, and conducted surveys for whales in the basin North of the Balearics, then transited to the Alboran Sea. There was a mid-cruise crew change in Malaga Spain followed by more work in the Alboran Sea, then a transit to the Tyrrhenian Sea before the end of the cruise 6 September 2009 in La Spezia.

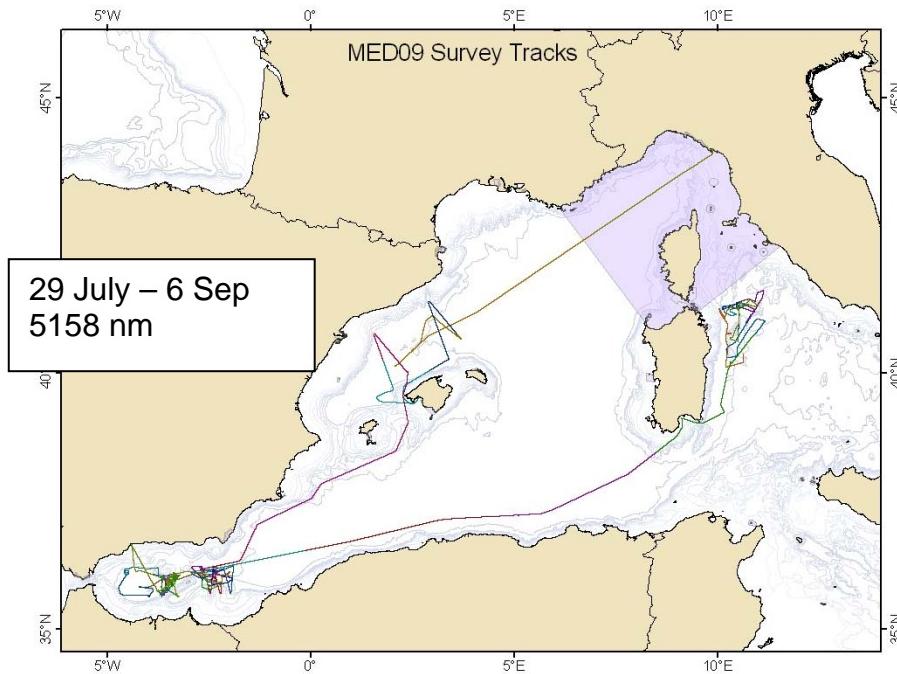


Figure 1. Cruise track for Med09.

The Med09 cruise involved a combination of visual and acoustic surveys (172.5 hours) and focal follows (85.2 hours). The surveys used a visual observation team with special focus on beaked whales, with a towed hydrophone array that was also well suited to detect beaked whale clicks. The passive acoustic monitoring used towed arrays from CIBRA, two small bearing arrays, and sonobuoys. The capabilities of the bearing arrays were tested and validated, and the sonobuoys were used to sample broadband noise in over the study area.

RESULTS

The Med09 included a very successful survey effort. Over 550 hours of passive acoustic monitoring were also collected from two towed hydrophone arrays capable of recording freq up to 90 kHz, with 53 contacts identified as *Ziphius cavirostris*. The survey N of the Balearic Islands yielded 1 sighting of 1 *Balaenoptera physalus*, 0 sightings but 2h55min of acoustic detections of sperm whales, 0 sightings but 6 min of acoustic detections of *Ziphius cavirostris*, 0 sightings but 34min of acoustic detections of *Grampus griseus*, 2 sightings of 13 *Tursiops truncatus*, 22 sightings of 265 *Stenella coeruleoalba*, 5 sightings of 60 *Delphinus delphis* or *Stenella coeruleoalba* and 2 sightings of 3 Undetermined Dolphin (and 19h18 min of acoustic detections). The survey in the east of the Alboran Sea yielded 27 sightings of 67 *Ziphius cavirostris* (and 4h36min of acoustic detections), 0 sightings but 42min of acoustic detections of sperm whales, 11 sightings of 168 *Globicephala melas* (and 1h10min of acoustic detections), 19 sightings of 89 *Grampus griseus* (and 2h32 min of acoustic detections), 11 sightings of 304 *Delphinus delphis*, 42 sightings of 870 *Stenella coeruleoalba*, 32 sightings of 454 *Delphinus*

delphis or *Stenella coeruleoalba*, 3 sightings of 16 Undetermined Dolphins (and 55h40min of acoustic detections), and 2 sightings of 2 Undetermined Cetacean. The survey in the west of the Alboran Sea yielded 25 sightings of 56 *Ziphius cavirostris* (3h40min of acoustic detections), 9 sightings of 71 *Globicephala melas* (32min of acoustic detections), 6 sightings of 38 *Grampus griseus* (1h2min of acoustic detections), 15 sightings of 222 *Delphinus delphis*, 30 sightings of 550 *Stenella coeruleoalba*, 64 sightings of 1233 *Delphinus delphis* or *Stenella coeruleoalba*, 1 sighting of 5 *Tursiops truncatus* or *Grampus griseus*, 3 sightings of 52 Undetermined Dolphins (66h10min of acoustic detections), 3 sightings of 4 undetermined Ziphiid, and 2 sightings of 2 Undetermined Cetacean. The survey in the Tyrrhenian Sea yielded 22 sightings of 27 *Balaenoptera physalus*, 18 sightings of 24 *Physeter macrocephalus* (4h40min of acoustic detections), 6 sightings of 12 *Ziphius cavirostris* (2h17min of acoustic detections), 1 sighting of 4 *Tursiops truncatus*, 1 sighting of 44 *Delphinus delphis*, 23 sightings of 366 *Stenella coeruleoalba*, 30 sightings of 288 *Delphinus delphis* or *Stenella coeruleoalba*, 2 sightings of 6 Undetermined Dolphins (30h42min of acoustic detections), 1 sighting of 1 Undetermined Balaenopterid, and 10 sightings of 10 Undetermined Cetacean. In surveys during the transits between these regions, there were an additional 127 sightings of 1082 individuals identified to species.

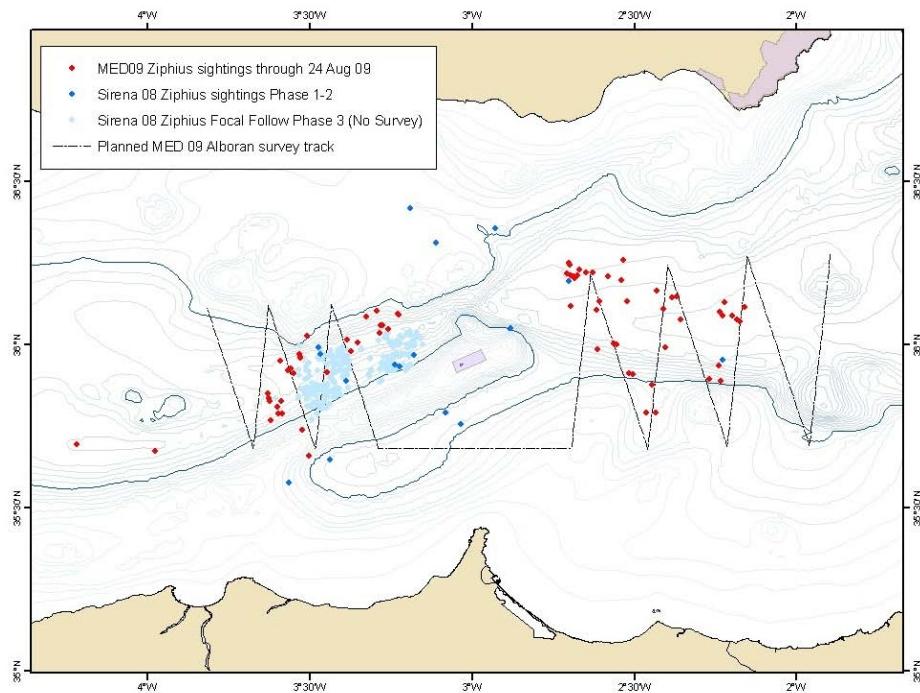


Figure 2. Sightings of Cuvier's beaked whale, *Ziphius cavirostris*, in the Alboran Sea, 2008-09.

Figure 2 shows the sighting data of *Ziphius* in the Alboran Sea from the Sirena08 and Med09 cruises. The density of *Ziphius* is quite high in this area. One of the most important capabilities to enable playback experiments using the protocols established in BRS call for the requirement of focal follows of beaked whales, coupled with the capability to record echolocation clicks of a group of beaked whales soon after it dives, and to determine when they stop clicking. 15 Focal follows of Cuvier's beaked whale were conducted in Med09, each lasting an average of about two hours. The visual teams and passive acoustic monitoring teams were able to routinely pass the focal animal from visual to acoustic monitoring. A significant new capability developed and validated during Med09 involved

using the towed hydrophone arrays to record nearly continuous series of echolocation clicks from a group of beaked whales that had been sighted when it started a deep foraging dive. By circling this point at a radius of about 500m, and modifying course depending on the direction of the clicks, the Alliance was able to determine when the group started clicking and ended clicking, the critical parameters for the playback protocol. This was the only critical capability for ship-based playbacks that had not been demonstrated before the cruise.

The tagging boat was deployed 17 times for tagging Cuvier's beaked whales, yielding a total of 400 pictures collected, 47 used in the catalog, and 17 individuals photo-identified. The tagging team was unable to tag a beaked whale, but did tag two pilot whales, *Globicephala melas* in the Alboran Sea on 7 August 2009. The first tag was deployed at 0901 and recovered at 1225; the second tag was deployed at 0913 and recovered at 1652.

IMPACT/APPLICATIONS

This study aims to reduce risks to whales and to improve monitoring and mitigation measures by identifying beaked whale habitats and by defining the mechanisms by which beaked whales and other species are affected by sonars. The cruise provided important survey data on beaked whales and other cetaceans in the western Mediterranean which will be used for habitat modeling. While this cruise was not able to tag a beaked whale and conduct a sonar playback, the cruise did demonstrate the required capabilities and trained the teams for conducting controlled exposure experiments outside of a Navy underwater range, where vocalizations can be recorded from a permanent bottom-mounted hydrophone array.

RELATED PROJECTS

ONR: Behavioral Responses of Odontocetes to Playback of Anthropogenic and Natural Sounds
N00014-07-1-0988

ONR: Cetaceans and Naval Sonar: Behavioral Response as a Function of Sonar Frequency. Grant Number: N00014-08-1-0661

SERDP: Acoustic Response and Detection of Marine Mammals on Navy Ranges Using a Digital Acoustic Recording Tag.

PUBLICATIONS

Canadas, A., Podestà, M., Pusser, T., Quero, M. E., Revelli, E., Tyack, P. L. 2009. Med09 focal follow operations visual team handbook.

Ciany, C. M., Rooney, J. III, Zurawski W. C., and Tyack, P. 2009. The Validation of Novel Mid-Frequency Sonar Signals Design to Reduce the Impact on Marine Mammals. *Journal of Underwater Acoustics* 59:47-70 [published, refereed]

D'Amico, A. D., Gisiner, R., Ketten, D. R., Hammock, J. A., Johnson, C., Tyack, P. & Mead, J. Beaked whale strandings and naval activities. *Biological Conservation*. [submitted, refereed]

Nowacek D. P., Thorne L. H., Johnston D. W., Tyack P. L. Responses of cetaceans to anthropogenic noise. *Mammal Review* 37:81-115. [published, refereed]

Southall, B. L., Bowles A. E., Ellison, W. T., Finneran, J. J., Gentry R. L., Greene Jr. C. R., Kastak D., Ketten D. R., Miller J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., Tyack P. L. Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals*, 33: 411-521. [published, refereed]

Tyack, P. Implications for marine mammals of large-scale changes in the marine acoustic environment. *Journal of Mammalogy* 89:549-558. [published, refereed]

Zimmer W. M. X. & Tyack P. L. Repetitive shallow dives pose decompression risk in deep diving beaked whales. *Marine Mammal Science* 23(4): 888-925. [published, refereed]

Zimmer, W. M. X., Harwood, J., Tyack, P. L., Johnson, M. P., & Madsen, P. T. (2008) Passive acoustic detection of deep-diving beaked whales. *J. Acoust. Soc. Am.* 124:2823-2832. [published, refereed]